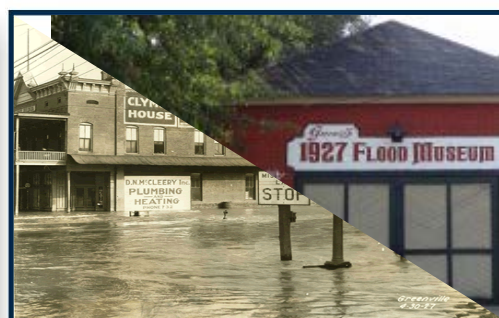
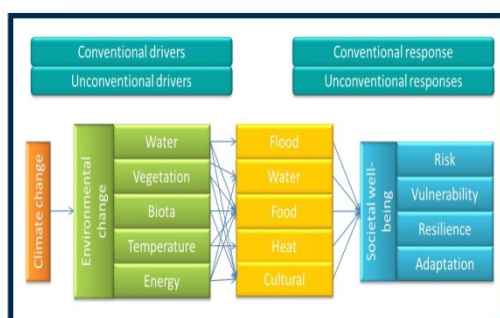
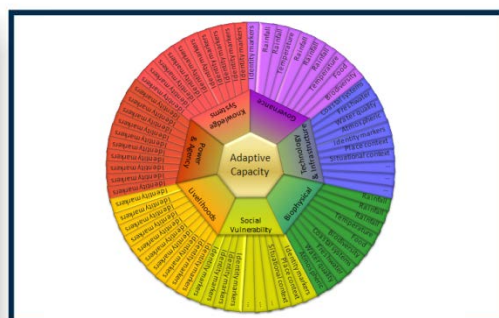


# CSIR Contribution to Defining Adaptive Capacity in the Context of Environmental Change

## Final Report

Approved for public release; distribution unlimited



# **CSIR Contribution to Defining Adaptive Capacity in the Context of Environmental Change**

## **Final Report**

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31 January 2016

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## **1. PROBLEM STATEMENT**

Adaptive capacity in response to environmental change has been highlighted by many initiatives, including the Intergovernmental Panel on Climate Change (IPCC), stating that adaptation options exist in all sectors, but some adaptation responses involve significant co-benefits, synergies and trade-offs. This reality was emphasized in the Executive Order 13677, where President Obama, requires agencies to factor climate-resilience considerations systematically into the U.S. Government's international development work and to promote a similar approach with multilateral entities. Amongst other, the order is intended to promote knowledge sharing in incorporating resilience considerations. In this context, the Engineer Research and Development Center (ERDC), through its International Research Office (IRO), awarded grant number W911NF-14-1-0113 to the CSIR. The grant is based on the premise that human security and environmental security is inextricably linked and that a better understanding the relationship between human and environmental security will assist in reducing vulnerabilities and improving stability. The grant supports CSIR and ERDC research in adaptation to water-related impacts of climate change. The grant supports a comparison of historic human responses to environmental change in the Mississippi River and the Nile River, as measured by human security indicator datasets and environmental variability data. The overall goal is to measure regional adaptive capacity and thus understand how to facilitate regional stability that can withstand threats imposed by environmental impacts. Based on the outcome of this analysis, a set of metrics will be developed that will assist in measuring the adaptive capacity of a region based on past behaviour and capabilities to cope with physical or environmental changes.

The research is focused on understanding and identifying vulnerabilities in developing regions that inherently have fewer institutional capabilities to handle large-scale changes. The qualitative and quantitative analysis of adaptive capacity compares areas in the Mississippi and Nile Basin. The Mississippi case area serves as a more controlled case study with the Nile Basin representing a context with more limited historical data. Environmental change and human behavior over the hundred year time scale (1910-2010) are being used for the analysis. The comparison of environmental change (eg. precipitation and temperature trends) and the corresponding human behavioural responses (eg. food access and migration patterns) will provide an input to metric creation, contingent on evidence that changes in local stability are related to environmental change. These metrics will be used to measure areas of vulnerability within both study regions.

## 2. PROJECT TASKS AND PROGRESS

### 2.1 Tasks

No.	Task	Description	Target date
1	Datasets	1.1 Inputs to environmental and human security datasets	31 Jan 2014
2	Data fusion	2.1 Data overlay	31 March 2014
2	Data fusion	2.2 Data analysis 2.3 Additional data collection	30 Sept 2014
3	Correlation	3.1 Compare results	30 Sept 2014
4	Metrics	4.1 Develop adaptive capacity metrics	31 March 2015
4	Metrics	4.2 Identify areas of vulnerability	30 June 2015

The specific details of the tasks were as follows:

Task 1.1: Gather and create environmental variability datasets from meteorological and hydrological observations for the time period (1910-2010) for both the Mississippi River and the Nile River. Meteorological data over the research areas will be gathered from Global Historical Climatology Network (GHCN) maintained by NOAA, 14th Operational Weather Squadron, the National Climatic Data Center (NCDC), along with the additional data sources listed in Table 3 and other data sources as provided by CCAPS. Data will then be combined from these sources to create a comprehensive database for each research area. The CSIR will assist with the data gathering, specifically for the Nile Basin and selected sub-region. Depending upon the database created, a partnership may be formed within ERDC, DoD, or academic community in order to facilitate provision of or creation of a re-analysis dataset. Use of a re-analysis dataset will depend upon information gathered in Task 1.2.

Task 1.2: Build a composite human security indicator dataset from the Global Human Security Index in conjunction with the other socio-economic and general population data tabulated above from 1910-2010 for both the Mississippi River and the Nile River. The CSIR team will contribute data to this task, which will be integrated into the dataset. All data will be combined and assessed using a mixed methods approach composed of both a historical analysis and a longitudinal study.

Task 2.1: Overlay the environmental dataset produced from the reanalysis with the historic human indicator data. This task will be done for both the Mississippi River and the Nile River. The CSIR will provide technical assistance with this task, which will be achieved through a joint workshop at ERDC.

Task 2.2: Determine if significant changes in environmental variability data correspond to changes in human behaviour using both visual (GIS) and statistical methods for each river. Use both the human security indicators and relevant historical case studies to find and affirm a correlation to tangible changes in environmental data. Due to the future transition of this research, past military involvement with populations residing within the watershed will also be researched and the impact will

be considered. This task will be facilitated through the joint workshop in which the CSIR will participate.

- Task 2.3: To further define and confirm correlative relationships between the two datasets, additional background research will be conducted to consider the following potential historical factors: man-made infrastructure alterations to each river, topographic modifications within each watershed due to urbanization, industrialization, and technological advancements, and changes in environmental policy relating to use of and disposal in the rivers. The CSIR will assist with this research particularly regarding the Nile Basin and selected study area.
- Task 3.1: The results from both historical analyses will be compared and contrasted statistically. For example, we could do pattern analyses and if possible conduct a regression analysis. We expect there to be vast differences between the two regions because of the innate socio-economical differences between developed and developing countries. However, if the results from both the developed and developing regions demonstrate that there are specific human responses to changes in the environment, then it is plausible to create adaptive capacity measurable framework that could be utilized in other areas of the world. The CSIR will provide inputs to the analysis.
- Task 4.1: Develop a set of metrics to measure human adaptive capacity based on successes and failures of past communities in both the Mississippi River basin areas and Nile River basin region of adapting to variability in the environment. This task will be conducted with support from the CSIR team.
- Task 4.2: Use the metrics to identify future areas of vulnerability within the Mississippi River basin and Nile River basin region. Utilize GIS to visualize these areas where there both exist opportunities for improving a community's adaptive capacity and potential for US military involvement. The CSIR will make inputs to the analysis.

## 2.2 Progress

- Task 1.1: The CSIR team conducted a broad survey of qualitative and quantitative data for the Nile and Mississippi case areas. Hydrological data was acquired from the Global Runoff Data Centre. The data includes average daily and monthly flow for the Mississippi River and Monthly average flows for the Nile River.
- Task 1.2: The ERDC together with the CSIR developed a composite human security indicator dataset using the Global Human Security Index as a basis from which to work. The Global Human Security Index has at its core seven categories that are made up of a number of sub-categories. The main categories are: economic, health, personal, community, political food and environmental. Taking the contextual nuances of the two case study areas, the Mississippi River and the Nile River, into consideration, the team (CSIR and ERDC) developed a new dataset which comprises of the following main categories: economic, health, personal, community, political, food, environmental, cultural/spiritual, physical infrastructure and livelihoods. Each of these categories also has sub-categories which are specifically linked to human adaptive capacity within the context of environmental change.

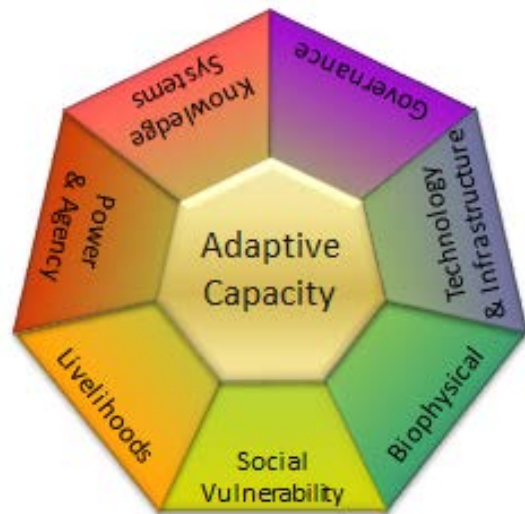
- Task 2.1: CSIR project members, Marius Claassen and Karen Nortje journeyed to Washington DC in February 2014 during the week of the 17th to the 21st. During this week the CSIR collaborated in a joint workshop with ERDC team members, Swathi Veeravalli (project leader), Laura Harding and Nicole Wayant. The agenda included an overview of the objectives and discussions on the data to consider the relationships and linkages over time and space for the two project case areas. The team refined the methodology, discussed joint participation in activities and access to datasets for both qualitative and quantitative, and environmental and human security factors. During this joint workshop the team tested the composite human security indicator dataset developed during Task 1. This dataset took into consideration the contextual nuances of the two case study areas, the Mississippi River and the Nile River. This new dataset comprised of a number of main categories, namely: economic, health, personal, community, political, food, environmental, cultural/spiritual, physical infrastructure and livelihoods. Each of these categories also had sub-categories which were specifically linked to human adaptive capacity within the context of environmental change. In order to test the new dataset, an excel spreadsheet was created where the team then input data both spatially namely, national, regional and local, and temporally according to decade.
- Task 2.2: During the 2nd to the 6th of May 2014, Swathi Veeravalli visited the South African team in Stellenbosch. During this week Laura Harding and Nicole Wayant joined in via telecom for technical discussions with the team. The qualitative data analysis team (Swathi Veeravalli and Karen Nortje) presented their findings with regards to the composite human security indicator dataset developed during Task 1 and Task 2.1. One of the main findings for the qualitative data analysis was the decision to interview the data as opposed to interviewing people. In order therefore to map the trends (as tested in Task 1 and 2.1), the qualitative team have developed a set of questions that captures the variables required, and yet is still flexible and embedded within the context:
- Task 2.3: In August (12-15) the CSIR team consisting of Marius Claassen and Karen Nortje travelled to Washington DC. During the team meetings Karen Nortje gave a presentation on the progress with regards to the Nile case example. One of the interesting findings reported related to the method, which was an understanding of the difference between data being “reported on” in literature and an event or issue being analysed and discussed in literature. It is important to develop a way in which to differentiate in the representation of the data. A finding related to our analysis was the need to develop a method relating to how to report on ‘value’ as embedded in the text being analysed.
- Task 3: One of the challenges of data fusion is to represent different data themes covering a 100-year period. The team developed a visualisation tool that allows the user to travel through a “time tunnel”, where different sources of data are presented for each time slice. The South African team, accompanied by Swathi Veeravalli also spent some time in the case study area of the Mississippi. Here the team used the time to visit the areas affected by hurricane Katrina in New Orleans which generated useful insights to the analysis of the literature accessed. In addition, the team drove up to Greenville (the specific site for the Mississippi case study) where they had the opportunity to interview local people with regards to their knowledge and

experiences of droughts and floods in the area. Again, these insights were crucial to ground the theoretical insights already garnered in the practicality of real-time examples. An interesting observation from the trip was that the engineering solutions (levees) along the Mississippi River have cut off people from the river, both in terms of the view of the river, and the perceived risks associated with the river.

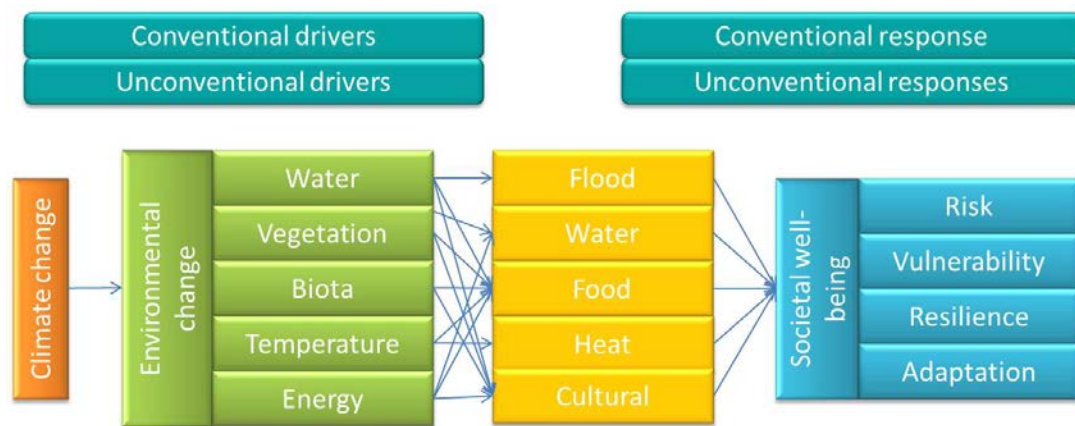
Task 3.1 The project team worked on the tasks from their respective offices, but also utilized several opportunities for joint work sessions. From the 24<sup>th</sup> to the 29<sup>th</sup> of August 2014, the CSIR team met with Ms. Veeravalli (ERDC) and Mr. Andrews (AFRICOM) in South Africa and Mozambique to work on the metrics related to Tasks 4.1 and discuss other issues of joint interest. The South African team members also visited the ERDC team in Washington DC from the 10<sup>th</sup> until the 17<sup>th</sup> of May 2015 to work on task 4.2. The team also had the opportunity to meet in the Seychelles from the 19<sup>th</sup> until the 23<sup>rd</sup> of June 2015 to develop the metrics further.

Task 4.1 The CSIR support for the development of metrics to measure human adaptive capacity was based on the information collected for the

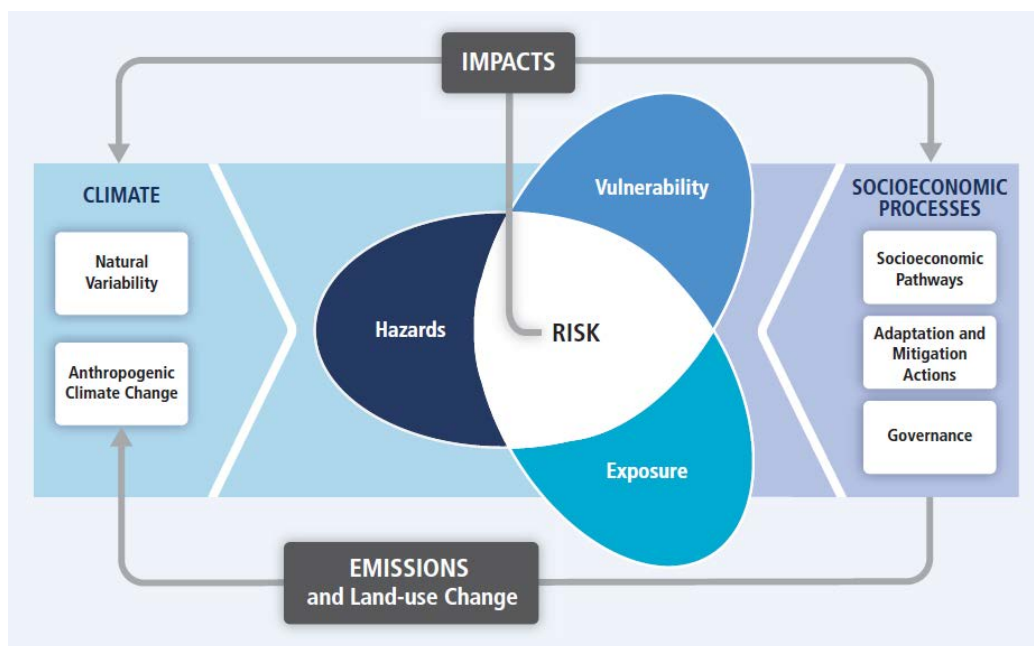
case study areas in the Mississippi River the Nile River. The 100-year history it was assessed in the earlier tasks provided a basis for the analysis, but also provided a practical context to evaluate existing frameworks, metrics and indicators. The evidence of societal adaptation to changes in environmental conditions in the Mississippi River basin areas and Nile River basin region focussed on significant events, such as floods and droughts, whereas adaptation to incremental



change (such as changes in vegetation) were not evident from conventional information sources. The seven metrics that emerged from the analysis are indicated in the adjacent figure. The metrics are evaluated through a set of indicators that are drawn from different reporting frameworks, but are also filtered in terms of the relevance to the case study areas. It is envisaged that an assessment framework will be produced that will also facilitate the evaluation of adaptive capacity in other contexts. The framework is presented in the figure on the next page.



Task 4.2: The metrics were used to identify areas of vulnerability within the Mississippi River basin and Nile River basin region. The IPCC (2014) simplified the relationship between climate and socio-economic processes and particularly the associated risk in the figure hereunder.



The opportunities for improving the communities' adaptive capacity (in accordance with the IPCC framework) relate to the reduction of the hazard, reducing the exposure to the hazard or reducing the vulnerability associated with the hazard. Whereas the reduction of the hazard (climate change mitigation) is important in the long term, this research is focussed on the exposure and vulnerability components. The analysis highlighted similarities and differences in the two case areas. In the Mississippi (Greenville) case, the river served as a trade and transport corridor, but also presented a risk through flooding. The chronology of adaptation in the Greenville case includes the extensive levee system, which reduced the risk of flooding, but also created a barrier between communities and the river. Greenville

was significantly affected by the diversification of transport and commerce, with subsequent socio-economic development challenges. In the Khartoum region of the Nile Basin, the 100 year history is more punctuated, with a complex political history being superimposed on instances of floods and droughts. While infrastructure was put in place to draw on the benefits from the river (e.g. irrigation and navigation) and protect communities from floods (e.g. levees), the ongoing political tensions had a negative impact on the sustainability of the infrastructure.

### 3. FUTURE COLLABORATION

The collaboration in defining adaptive capacity in the context of environmental change (DACE) provided a sound foundation for future collaboration. The CSIR participated in the development of a new research proposal with ERDC. The research will focus on interdisciplinary science and technologies for incorporating human-environment interaction with climate change to conduct vulnerability assessments exist in very limited scope. Such S&T are confined to the global scale and are not adaptive to regional and community scales. Additionally, this same S&T is rooted in two or less disciplines and do not span various disciplines. As a result, the creation and evolution of S&T are confined to homogenous and independent systems that then must somehow simultaneously interact to support defense, diplomacy and development activities. In this manner, this research project is focused on developing knowledge to civil-military stakeholders to effectively understand the security implications of human insecurities. As the problems of vulnerability and adaptive capacity are inherently interdisciplinary, so must solutions to address these same issues. This research is focused on developing the knowledge for effectively building and evolving research for distributed inter-organizational systems and by distributed multi-organization teams. As the problem is intrinsically interdisciplinary, so is the approach. This project will create novel S&T based upon an integrated social-ecological systems perspective. The project will be empirically grounded through research partnerships with various organizations.

### 4. COST AND PAYMENT SCHEDULE

#### 4.1 Cost and Price

Type of Report	Due Date	Amount of
1 <sup>st</sup> Interim Report	1 month after grant start date	\$7,000.00
2 <sup>nd</sup> Interim Report	3 months after grant start date	\$13,000.00
3 <sup>rd</sup> Interim Report	10 months after grant start date	\$5,000.00
4 <sup>th</sup> Interim Report	14 months after grant start date	\$30,000.00
Final Report	18 months after grant start date	\$5,000.00

### 5. PROJECT TEAM

Dr Marius Claassen CSIR

## 6. OUTPUTS

- Claassen, M. 2015. Quantifying the benefits of transboundary water cooperation in the Nile Basin, presentation at the Horn of Africa Water Security Workshop, jointly hosted by the USGS, USAFRICOM and NAVFAC, 24-28 August 2015 in Addis Ababa, Ethiopia.
- Claassen, M. 2015. Transboundary Watershed Management Incorporating DRM, presentation at the Environmental Law and Coastal Resiliency Symposium, jointly hosted by the United States Africa Command (USAFRICOM) Environmental Security Program, and the United Nations Environmental Program – Abidjan Convention Secretariat, 16-20 November 2015 in Dakar, Senegal.
- Claassen, M., Andrews, J., Sinicrope, J., Jhon L (2015) Ground Zero: Water Security in the Nile Basin. Book Chapter
- Claassen, M., Nortje, K., Veeravalli, S. 2016. A Framework Linking Adaptation Options to Environmental Change through Societal Risks and Vulnerabilities. Draft manuscript
- Nortje, K. 2015. Assessing and Leveraging Existing Capacity, presentation at the Environmental Law and Coastal Resiliency Symposium, jointly hosted by the United States Africa Command (USAFRICOM) Environmental Security Program, and the United Nations Environmental Program – Abidjan Convention Secretariat, 16-20 November 2015 in Dakar, Senegal.
- Nortje, K., Claassen, M., Veeravalli, S. 2016. Metrics and indicators for practical application of data on environmental change to societal risks, vulnerability and response options. Draft manuscript